GENERAL NOTE

Art, Science and Communities of Practice

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ABSTRACT

Through editorials such as Bob Root-Bernstein's ArtScience "manifesto" in *Leonardo* Vol. 44, No. 3 (2011), *Leonardo* has long encouraged a broader and more inclusive understanding of the subtle interplay between science and art, and the belief that as individuals and cultural agents we all blend both aspects in our respective fields of endeavor. However, discourse and collaboration across the arts, sciences and humanities is not yet a mature and fully effective process. The authors contribute to this debate by drawing on elements of their Project Dialogue research program, set alongside published accounts of experiences at earlier U.K. art-science programs, to sketch out a theoretical framework that could inform ArtScience through a re-formulated cultural model of knowledge encompassing art and science.

THE AUTHORS AND THEIR APPROACH

Through previous collaborative projects, the authors of this paper have listened to, assimilated and responded to each other's arguments, criticisms and conceptual models with much closer attention than is typical between practitioners in science, philosophy and art education. Appreciating more clearly how other disciplines go about their "ways of knowing" has helped to bring into sharper focus the knowledge, values and boundaries associated with our respective research communities. Discovering how the foundational assumptions and ideological baggage of one's own field of research are seen through the eyes of practitioners from other disciplines helps to reveal underlying commonalities in research processes and broadens our perception of the relationship between the arts, sciences and humanities. An analytical auto-ethnographic approach of this nature [1] therefore promises valuable insights into how the growing relationship between art and science could evolve into an even more fruitful knowledge paradigm.

We established Project Dialogue in the Faculty of Creative Arts at the University of the West of England, Bristol, U.K., in 2006 to offer a contemplative space for exploring the underlying commonalities between art and science through a rolling research program and invited seminars from a wide range of speakers. Co-author and recently retired scientist Brett Wilson presented a number of seminars looking at the cultural history of scientific ideas alongside the more usual visual culture material to initiate a broader debate on art and science as related communities of practice rather than as separate research tribes. This paper summarizes a number of the key concepts explored in our research program that can help inform the ArtScience movement [2]. Figures 1 through 3 and the Article Frontispiece are images of artwork by artists who contributed to Project Dialogue's 2010 seminar series and to our recent book *Art, Science and Cultural Understanding*, which grew out of that collaboration [3]. These four artists are representative of a new generation whose involvement in various scientific fields is being used to frame fundamental questions about the nature of human perceptions and identity through their artworks.

PRODUCING KNOWLEDGE: STUDIO AND LAB PRACTICE

Sciart, funded by the Wellcome Trust, and the Art and Science Research Fellowship, run by the Arts and Humanities Research Council/Arts Council England, are two examples of typical art-science schemes that took place in the U.K. over a 10-year period, ending in 2008. Subsequent independent evaluation of the Wellcome Trust's Sciart program [4] noted that while participants had learned something about each other's disciplines as a result of collaboration, they had generally not developed any additional insights into their own

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Article Frontispiece. Susan Aldworth, *Elisabeth*, monotype, 250 x 200 cm, 2012. Exhibited at the National Portrait Gallery, London, as part of the exhibition *The Portrait Anatomised* (March–September 2013). Growing out of residencies at hospitals and clinics, Susan Aldworth's work frequently explores how new scientific imaging techniques impact our understanding of the relationship between contemporary notions of self and the physical brain. (© Susan Aldworth. Image courtesy of the artist and GV Art, London.)

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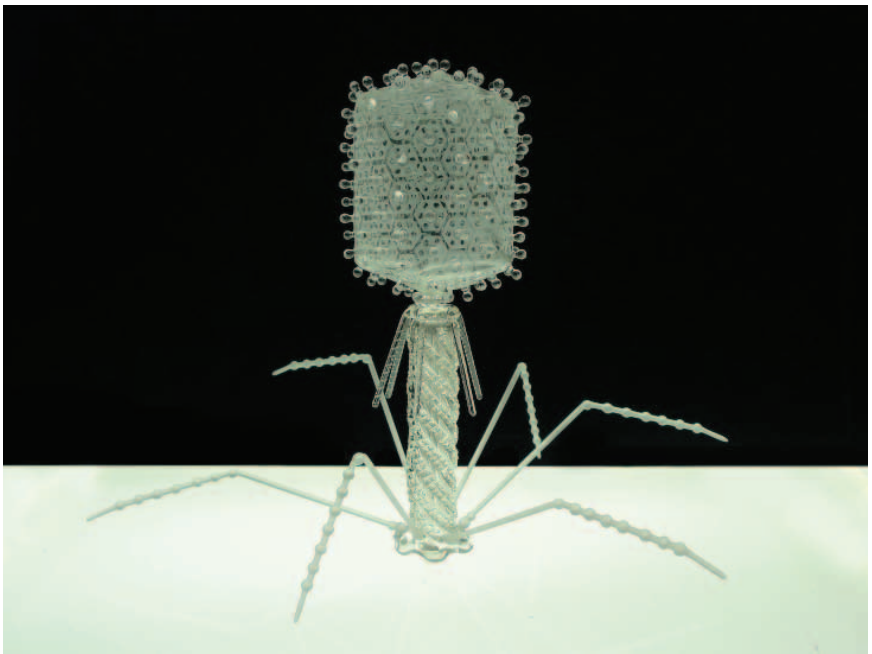

Fig. 1. Luke Jerram, *T4 bacteriophage* in glass, 2011. Luke Jerram's 3-dimensional representations of permeable, almost invisible, colorless and semi-transparent glass virus sculptures have altered the visual vocabulary of virology, in both the public and scientific arenas. (© Luke Jerram)

practices. However, it was widely felt that the schemes had been valuable in fostering experimentation, resulted in increased levels of risk-taking and had shown that innovation in process was as important as the finished product. Other published accounts described how both collaborating scientists and artists saw the role of scientists as being to uncover previously existing objective evidence in a physical world, while both parties agreed that artists, through their labor and original creativity, were producing artifacts that embodied some form of inter-subjective cultural expression [5].

In our early debates, Project Dialogue graduate students and early-career researchers similarly voiced the opinion that scientists were discovering and harnessing something that had always been there for the finding, whereas artists were creative because they conjured up something personal and novel from within their own minds. In contrast, when looking at science and art as related communities of practice through our Project Dialogue workshops, we found agreement that there were numerous tempting parallels to be drawn between the "culture of experiment" in art and science. Studios and laboratories could both be described as places of discovery and curiosity—places where new conceptual structures and investigative methods were explored; where mastery of craft and expert judgement played important roles; where new metaphors could illuminate unexpected directions and consequences; and where teasing obliquely glimpsed possibilities into working artifacts was often decisive. Crafting a work in progress towards a state of exhibition, inspection and judgement by fellow professionals, sponsors and the wider public was a strong driving force for scientists and artists alike. Artists and scientists often more strongly identified with being practitioners directly involved in research than they identified with the specific traditions of their own individual fields of practice.

So while there appears to be common acceptance of fundamental differences between art and science on the one hand, there is also general agreement that the two endeavors share many similarities when viewed as communities of practice. It seems that much of the background philosophical framework of both scientists and artists has been inherited second-hand from a previous age. The economic, industrial and intellectual expansion in the West that characterized the 17th-century Enlightenment program was crucially dependent on the disenchantment of science—in which matter effectively became "de-animated"—but it did not depend on the idea of objectivity. The notion of "mechanical objectivity" was only adopted in scientific enquiry around 1830, following the previous "truth to nature" standpoint, and only lasted for just over a century before evolving into the current ideas of "expert judgement" [6]. Yet the notion of objectivity still seems to impart a powerful influence on what contemporary scientists, artists and the general public take to be "modernity," where utility is expected of science through technology to fuel never-ending growth. In contrast, art is seen as an aesthetic expression of inter-subjective knowledge, personally created by the artist. Greater emphasis is now being placed on utility throughout the arts as well as the sciences under the present neo-liberal economic doctrine, with art increasingly being judged and funded on its profit potential rather than its aesthetic qualities.

WHAT IS RESEARCH?

The recent growth of arts-based, practice-led doctoral research has raised a number of pressing questions within the academy about what actually constitutes research and how it should be presented and evidenced [7]. Presenting visual, aural or performance-based material as an integral element alongside a text-based thesis to form part of an arts research program for evaluation is, in principle, essentially no different to a traditional scientific Ph.D. In both cases candidates need to demonstrate how investigative laboratory experiments or innovative studio works constitute creative artifacts that act as respective sites of discourse, embodying and exercising the central research question under study using language specific to the inquiry. Both represent the public face of private imagination acted out through cultural processes, and the closed-loop path that is considered such a distinctive feature of scientific inquiry is clearly evident in the debate, review and critique adopted by contemporary arts-based, practice-led reflexive practitioners.

The approach we have evolved through Project Dialogue to the question of what constitutes research in general across diverse communities of practice is that it challenges fundamental structures, models and metaphors in one way or another, or proposes a conceptual model where none has previously been acknowledged. All research proceeds by asking explicit or implicit questions, and it is the nature and quality of these questions that determine the usefulness of the outcome. To get good answers, first one has to learn to ask good questions; to discover powerful paradigm-shifting answers, one needs to devise extremely insightful questions.

METAPHORS AND CONCEPTUAL MODELS

Science has recently taken a more considered attitude to its underlying epistemology, absorbing some of the concerns of postmodernism along the way. It has eventually accepted that scientific research is not simply a cosmic treasure-hunt for pre-existing knowledge objects embedded in some form of theory-independent reality, but is crucially dependent on the conceptual models we create to make falsifiable predictions for interacting with the world—from cosmology to how the brain functions [8]. Detailed and painstaking experimental work is vital, but we must never forget that observational data do not exist in a universal theory-free vacuum. As Einstein commented to Heisenberg: "It is the theory which decides what we can observe" [9]. The quantum world, for example, was not discovered as a self-contained and ready-packaged entity, it took many world-class scientists decades to create and refine the conceptual models required to make sense of it. The quantum world as we understand it today is just as much a crafted product of human imagination as it is a physical one. Whether science is inherently self-limiting in what it can ever know is also a question both scientists and philosophers are currently exploring [10].

Science has also only belatedly appreciated the role metaphors play in constructing its own conceptual models, despite the fact that linguistic metaphors abound across the arts and humanities and visual metaphors have long been powerful conceptual tools for visual artists. Writers such as Barbara Maria Stafford argue that consciousness is the *art* of connecting [11], echoing Steven Mithen's suggestion that modern humans are characterized by their evolved "cognitive fluidity" arising from a highly plastic and figurative general intelligence [12]. Appropriate metaphors and analogies (part of Todd Siler's family of figurative "metaphorms" [13]) help scientists, artists and other practitioners to link experience, intuition and imagination when erecting conceptual scaffolding for moving into new realms of the "not-yet-known-or-experienced," where literal language on its own may be insufficient. A well-chosen metaphor often illuminates a problem in a way that literal language simply fails to do and frequently suggests fertile new directions for study—as with the planetary metaphor of the atom, for example.

Accepting that models and theories are metaphorical constructs intended for mapping onto aspects of the observational domain also helps us to see how science works as a knowledge system. No single conceptual model need aspire to be a complete description of reality capable of capturing all the various observations that might be made. We happily use different atomic metaphors when considering the physical and chemical properties of matter, for example [14]. Consequently, approaching scientific models more as extended conceptual metaphors structured for predictive purposes through theory formation rather than direct literal attempts at mimicking some form of external reality also removes the requirement for any access to a contentious "objective" world

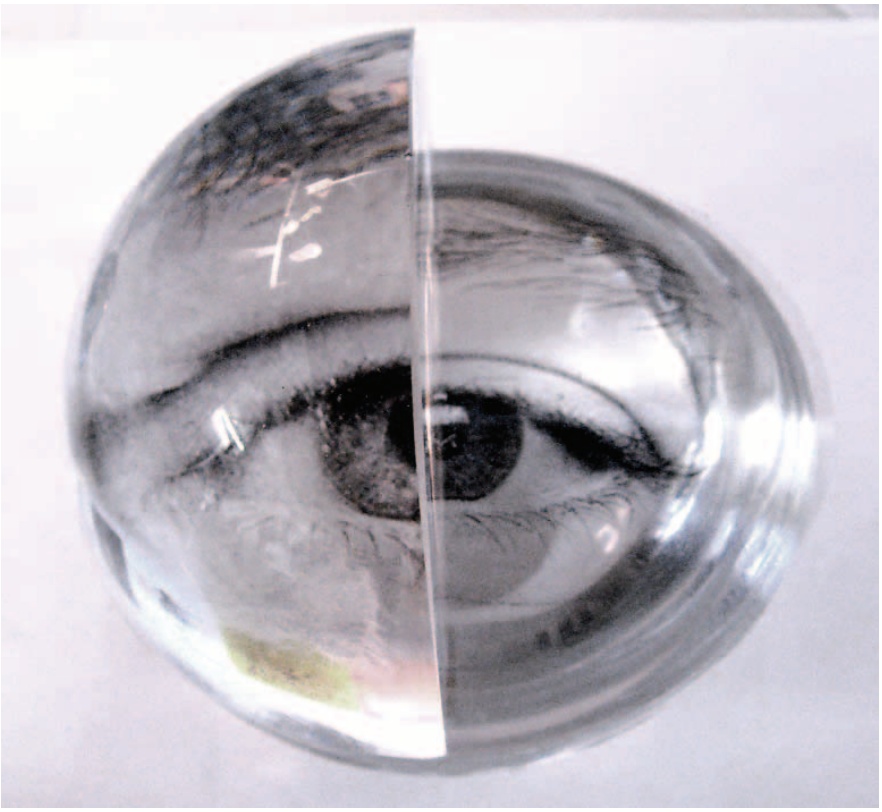

Fig. 2. Shelley James, *Lacuna 2*, print in hot glass, 10-cm diameter, 2010; glass blown by Liam Reeves. Shelley James creates intimate small-scale glass sculptures relating to the eye and vision. Her sculptures have produced a closer sense of personal engagement between patients, medical staff and the clinical environment through their ability to open up multiple perspectives. (© Shelley James)

with its implied notion of a privileged frame of reference that offers such a tempting target for cultural commentators. Our next step should be to acknowledge that since no model and its metaphorical base can therefore expect to be universally true, *all* models should be treated as provisional and not be expected to last *in perpetuity*—a point implicitly supported by both Kuhn and Popper [15]. Recent confirmation of the Higgs boson and its properties has sent many theoretical physicists back to their drawing boards since it represents the final piece of their Standard Model jig-saw puzzle: This completed model still has little to say about the growing puzzle of Dark Matter and Energy [16].

The appropriation of scientific concepts by philosophers, artists and cultural theorists is often criticized for being imprecise, when it could instead be viewed as an attempt to use those concepts in a figurative way that makes us rethink our assumptions about reality, generating interesting new questions in the process. That metaphors are now regarded as central agents in developing new conceptual models in the sciences as well as the arts further highlights the commonality of creative thought and that the arts, humanities and sciences should not be viewed as separate intellectual realms based on immiscible modes of thinking. Accepting that science also is built on both figurative and literal modes of understanding opens the door for a genuine aesthetic of science to emerge.

BAYESIAN EPISTEMOLOGY

Project Dialogue has also been about unpacking aspects of the assumption that art and science have divergent notions of truth and knowledge. One very promising step forward was made with a concept initially explored by Thomas Bayes in the 18th century and refined shortly afterwards by Laplace before being taken up by Alan Turing to help crack the German Enigma code in World War II. By this route Bayes's idea of how we handle incomplete or uncertain information eventually found its way into machine learning and artificial intelligence, then into the fields of neuroscience and visual perception. Initially slow to be adopted, it now has widespread practical uses in applications such as spam filters, search-and-rescue patterns and machine translation algorithms to search for best-fit solutions with incomplete information [17]. A Bayesian approach to epistemology effectively recognizes that real-world theorizing is neither purely objective nor purely subjective in the traditional sense, but utilizes both approaches when we wish to make useful predictions involving less-than-certain information. It offers an iterative route to incorporate experience with already-established information to create an improved belief capable of further testing and refinement. Bayesian epistemology's analytical combination of the not-quite-objective with the not-quite-subjective mirrors how cognitive science now accepts that embodied human problem-solving probably evolved [18].

Perceptions in general are now being viewed as Bayesian constructs that we adopt as a provisional hypothetical framework when testing sensory data for inconsistencies and interpreting for potential meaning [19]. Normally we remain unaware that we unconsciously treat perceptions as working hypotheses (i.e. informed guesses) but accept them as true and accurate representations provided by our eyes-as-cameras. Occasionally we perceive the struggle when two different hypotheses appear to fit the data equally feasibly, as with optical illusions involving Gastrow's ambiguous duck/rabbit figures and Necker's cube, for example. Here our brains consider each of the two possibilities in turn, giving us the distinct impression of jumping between two alternate, yet equally valid, views of the world. As neuroscientist V.S. Ramachandran remarks, "It's as if each of us is hallucinating all the time and what we call perception involves merely selecting the one hallucination that best matches the current input" [20].

The principal weakness of traditional epistemology has always been that it deals with knowledge as absolute certainty and is incapable of recognizing doubt, suspicion or "maybes" that form such a valuable part of our everyday detective kit. However, it is now possible using Bayesian calculus to explore quantitatively how our credence in a proposition is affected by new information when we attach varying degrees

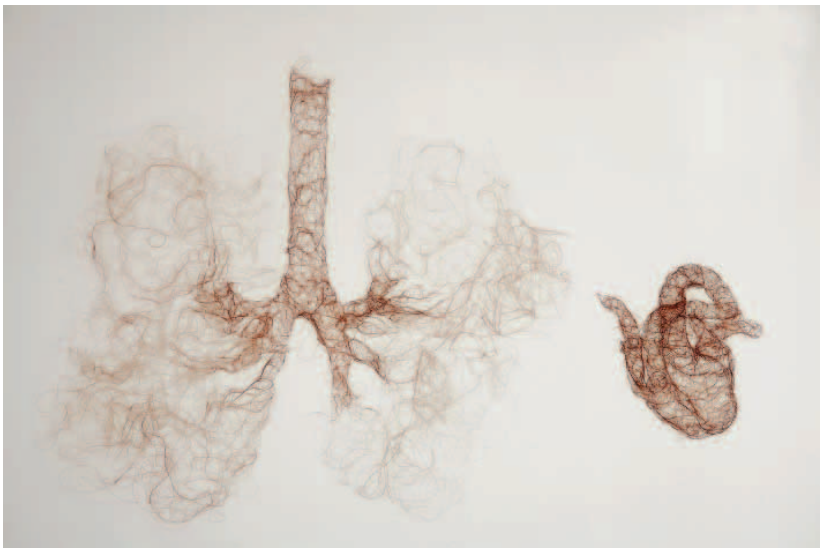

Fig. 3. Helen Pynor, *Untitled (heart lungs)*, knitted human hair, 25 cm (h) × 40 cm (w) × 15 cm (d), 2007. Helen Pynor's catalogue of work raises intriguing questions about the sense of ownership and identity invested in our bodies and internal organs, questions that often become very personal and pressing to recipients of transplant organs. Her joint installation and performance work with Peta Clancy, *The Body Is a Big Place*, explores this theme by involving members of the transplant community alongside the spectacle of re-animated pig hearts. (© Helen Pynor. Photo: Danny Kildare. Image courtesy of the artist and Dominik Mersch Gallery, Sydney.)

of belief to the new evidence, thus strengthening traditional epistemology. By combining prior assumptions alongside new experimental evidence to make iterative predictions, Bayesian calculus effectively allows us to blend both subjective and objective elements and is applicable to both sensory and cognitive domains.

We have recently proposed that theories and conceptual models formulated by humans can also be treated as formalized versions of internalized Bayesian constructs, deliberately and consciously set up to make sense of our cognitive world, mirroring the way we already perceive and respond to sensory data [21]. These external theories and models should similarly be treated as provisional ways of seeing the world and trying to make sense of it, accepting that a degree of uncertainty in our theoretical framework naturally translates to a provisional view of the world that must be tested for predictive and interpretive powers against both new information and other theories. Accepting all theories as provisional means that we do not treat them as permanent truths, but anticipate they will be challenged, revised and eventually replaced as new experimental evidence or improved theoretical constructs become available, thus ensuring that no one theory can become elevated to the status of unchallengeable dogma. The idea of provisionality works well in our search for a broader research context across art and science, as it satisfies Popper's requirements of constantly probing and testing hypotheses through a falsifiable model, as well as Kuhn's notion of replaceable paradigms.

CONCLUSIONS

Art and science not only share many similarities when viewed as communities of practice, they also display much stronger general theoretical underpinnings when we step back and view them both from a distance. In particular, sensory and cognitive frameworks built around Bayesian constructs are coming to replace previous concerns over the subjective/objective divide often felt to separate science and art, encouraging a broader cultural epistemology of the world to emerge, on which our conceptual models and metaphors may be based.

Acknowledgement

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Unedited references and notes as provided by the authors.

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2 *Leonardo* has been publishing in this field for over 50 years, during which time it has offered a platform for movements and programs aimed at trying to break down the conceptual, organizational and publishing barriers between the arts and sciences. This article was prompted by Bob Root-Bernstein, Todd Siler, Adam Brown and Kenneth Snelson's article "ArtScience: Integrative Collaboration to Create a Sustainable Future," published in *Leonardo* Vol. 44, No. 3 (2011), which resonated strongly with our own research program.

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